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RESIDENTIAL SOLAR ADDITION

Prepared for

MONTANA DEPARTMENT of NATURAL RESOURCES and CONSERVATION

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RESIDENTIAL SOLAR ADDITION

Prepared by

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June, 1982

Prepared for

Montana Department of Natural Resources and Conservation
32 South Ewing, Helena, Montana 59620
Renewable Energy and Conservation Program
Grant Agreement Number 056-811

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FINAL REPORT on grant to DAN AADLAND, Ph.D. (Grantee/Project Coordinator)
by Department of Natural Resources, RAE Program, Energy Division,
Agreement #RAE-056-811; Submitted June 1, 1982.

Enclosures: A) Final funding request
B) Photo history of the project

I. Objective

Objectives in submitting this grant were to build an addition to our Montana ranch home that could be a proving ground for several alternative energy ideas of which we had read and written. We wanted added space without added energy drain, and we wanted to combine alternative energy ideas in ways we weren't sure had been done in the past. Thus the addition would be of modified post and beam construction, it would use a trombe wall that would also furnish thermal mass to hold wood heat, and it would be passive solar heated. We would attempt laminating some of the structural supports ourselves. The outstanding feature would be double use of the same thermal mass: solar collection and heat sink storage for wood heat.

II. Implementation

Planning commenced several years before the grant was written. As energy writers/editors my wife Emily and I had developed materials for training energy auditors and had edited a comprehensive alternative energy manual for A.H.P. Energy Associates of Minneapolis. We also wrote Dwelling with Conservation, a booklet distributed by utility companies to homeowners.

Naturally, we began to look at energy use in our small ranch home. With three growing boys we needed more space, but we also wanted to improve our energy stewardship. We began to plan an addition that would either result in no increase in energy use or in an actual decrease.

Our planning culminated in our grant request of September 1980. Work began in May of 1981 after spring rains had subsided. Since the theme of the project was homeowner fabrication, we built the concrete forms, designed to be reused as the project progressed. We hired a local backhoe operator to dig trenches for the footings, then formed for them and called the concrete supplier. On his way in our bridge collapsed--we got him unloaded and out but then had to fix the bridge before work could continue.

Four pours of concrete later we had footings, foundation walls, a solar collection pad, and the lower four feet of the trombe walls (as high as the truck could reach). This concrete represented the bulk of the alternative energy "system", for it served as the heat sink to store both solar and wood heat energy. To make it better able to perform we insulated both under and around the collection pad with three inches of polystyrene rigid board insulation. We had heard of solar structures using crawl space for storage and having problems. No amount of perimeter insulation will prevent heat from being conducted downward, so some thermal break in that direction is needed. Our pad/trombe wall complex has insulation in all directions including between itself and the foundation wall. It is only bare within the room itself, so it gives up its heat to the interior.

By July '81 we were laminating posts for the corners and a column to fit along the old house to bear one end of the structural triangle. A bid for laminated beams from Timberweld of Columbus, Mt. was so low we could not realistically contemplate laminating them ourselves. A contractor helped by hoisting the beams in place while we secured them.

Framing continued in July and August. We laminated an additional post to carry the weight of the loft corner. The rest was framed conventionally but with 2x6's to provide more room for insulation. By Labor Day we were ready to shingle, and volunteer help from friends completed the task.

Roughed in, we were now able to turn again to energy-related matters. We installed R-19 fiberglass in the walls and R-30 fiberglass between the rafters. 1½" polystyrene was used between the floor joists. Additionally, we insulated and framed the rock wall on the old portion to prevent its carrying heat outside.

Solar collection in the structure relies on a south window wall, and the glass was now installed. A high-quality wooden patio door with double glazing formed the center panel. Ten 2x6' double-glazed, commercial quality thermal panes completed the wall. We framed them into the structure ourselves. We opted for double rather than triple glazing, for our studies show triple glazing loses more in solar transmission value than it gains in R-value.

A Scandia fireplace insert was installed against one of the trombe walls to form the central component of the Russian fireplace. The wood-heat complex will be evolutionary, so we can study its efficiency progressively, stopping when we have the right combination. Stage one (current) uses the concrete thermal mass as a backing for the cast iron insert. Thus the trombe wall absorbs wood heat on the north side and solar heat on the south side. Informal testing this winter (before the structure was fully insulated) suggested this stage was quite effective. Between its built-in blower system and the thermal absorption of the trombe wall we seemed to be gleaning more heat from a given quantity of wood than we were in our other (highly successful) wood stove in the older section of the house.

Stage two is to direct flue exhaust through the masonry itself to regain heat that would otherwise be lost up the chimney. This will be done somewhat cautiously, for we do not want to regain so much of the heat that the upper, metal part of the chimney develops creosote problems. Thus we will start with just two baffles (smoke passages), closely monitoring flue temperatures. If additional baffles seem justified we will add them. If not, we'll leave well enough alone.

Also in the category of system testing is the eave structure on the south above the thermal panes. We designed the overhang based on our latitude so that the winter sun would squarely strike the trombe walls while the summer sun squarely missed them. We appear to have been "on the money." As this is written we approach the longest days, and the sun is just touching a small portion of the solar collection pad in front of the trombe walls. This is of little concern, cool as our climate is, and it is doubtful further protection against unwanted summer sun is desirable.

Overall, system performance data (in addition to that mentioned above) must be very fragmentary at this point for two reasons: 1) The completed system has not yet lived through a winter, and 2) concrete, as a solar collector, must be pretty thoroughly cured for full effectiveness. (This takes about a year, and the mass will continue to improve after this.) However, we can make the following observations: Direct solar gain was extremely impressive during winter when the structure was not fully insulated and no openings into the old house had been made. The addition could be near the freezing point as day dawned, but if the sun shone be well up in the sixties a few hours later. Even on cloudy days the heat between thermal panes and trombe walls felt impressive.

Similarly, trombe wall gain was impressive, even though the walls were sitting on a concrete mass that was quite cold at that time. Inside trombe wall temperatures of over 70 f. were reached quickly, even though heat was being conducted to the colder concrete mass below.

Cost records "to the penny" were kept throughout the project and reported on in our funding requests and quarterly reports. (All cost records are available and on file.) System cost is hard to separate from cost of structure as the two are intertwined. What we have is a home addition that would cost X amount if no solar provision were made. The system cost, thus, must be that of the components that would be unnecessary in a conventionally-heated structure. This boils down to just three components: 1) concrete (above that needed for footings and foundation walls); 2) glass (beyond that needed for conventional lighting); and, 3) thermal window shutters to prevent heat loss through the glass at night. Concrete cost for solar pad and trombe walls was $575.75. Additional glass was approximately $600 plus $200 for framing and caulking materials, a total of $800. Thermax for the interior window shutters along with framing materials and magnets cost approximately $310.00. Thus the total additional cost--cost that made the solar identity of this project possible, was only approximately $1685.75. This is a very low figure and should be held in mind, for many still think of solar construction as expensive.

There is a very large X factor, however, and that is labor. The unconventional design of the project made it labor-intensive. The Aadland family built this addition with very little professional help, and that was primarily machine hire. Sheetrocking was done by professionals, but the labor there was not a grant item. We have no way of pricing the approximately 1000 hours of owner labor the addition represents. Perhaps a professional would have worked faster, perhaps not. We have one clue: a contractor two years earlier bid for us a much smaller, conventionally heated structure at $16,000. Our grant funds were $10,000, and we estimate $6,000-$8,000 of our own funds will eventually be spent. Thus, a cost parity seems to exist. We feel passive solar, if you plan for it, is not expensive. I think I could design passive solar houses costing little if any more than conventional houses, and our addition seems to substantiate this.

Economic evaluation is also difficult. The sun and cottonwood trees we already own will heat our home. Payback, if we use the above figure for cost excess over a conventional addition of the same size ($1685.75) would be less than three years, for our heat bill (oil) for the old house of only half the total size had been at least a third of this figure if one computes with today's oil prices. Payback for passive solar seems very fast and also deceiving--what other method of heating is asked to pay for itself in saved fuel?

The only possibility for system cost reduction I noted is in glass. We saved a great deal by purchasing thermal panes from Montana Glass in Billings and installing them ourselves (rather than buying completed windows), but one can save even more with patio door replacement units. They seem to be the lowest cost source of double glazing available.

III. Conclusions and Recommendations

I believe the project will do everything asked of it, including providing favorable P.R. for passive solar. It has generated a great deal of interest. I would suggest the following, related to both our project and others similar:

1) For below grade insulation buy name-brand Styrofoam instead of the low-cost bead-board (expanded polystyrene). Tests show the more expensive blue board has higher below-grade retention of R-value.

2) Be flexible. We planned use of rough-cut lumber and hand-laminated beams, but because of the building slump finished lumber and professionally-made beams were actually cheaper!

3) For passive solar in Montana avoid slantwalls--our sun is so low they gain little while inviting leakage. Similarly, shorten the large eaves shown on Colorado-oriented designs. Our summer sun is so high they aren't needed.

4) Area for further development: does it pay to route cold well water through a solar collection mass to save energy in the hot water department? Would cooling the mass this way in summer act as a passive sort of air conditioning? We intend to eventually find out.

IV. Monitoring

Beginning in fall of '82 we will log in outdoor and indoor temperatures at key times during each day. Readings on the thermometers imbedded in the solar collection mass will be made at these times and also recorded. If a fire is built its duration will be recorded as will masonry and flue temperatures of the Russian stove. Hours of direct sunlight will be noted. Conclusions drawn from this data will be available to the Department and forwarded when desired.

V. Public Availability

We will ask the local newspaper editor, who is already very interested in this project, to do a story on it in July. At that time, if it's agreeable with the Department, we'd like to announce the first Saturday and Wednesday of each month as visiting days, beginning in August. If these do not fit the Department's desires, just notify us. We have already shown our work to many mostly local people. Former senator Dick Colberg, who we understand co-sponsored the bill under which this grant program began, visited during August '81 and was extremely complimentary. The typical reaction of lay people has been difficulty believing solar can be so simple. Most expect complicated machinery and exotic components. Glass and concrete are too simple to be believed. Best success results from explaining that any south-facing glass window is a solar collector, that one need only to find a way to store the heat and keep it from escaping outside.

IV. Program Evaluation

We have nothing but good to say about this program and the Department. Your personnel have been helpful and cooperative. You have not buried us in required paper work. The young lady who visited us gave notice she was coming and was interested and courteous. I truly believe in what you are doing--putting some funds from energy leaving the state into projects within the state--and hope legislators allow you to continue. Lastly, please resist pressures to oversupervise, to make impossible the dream of the talented but perhaps eccentric individual who may not be talented at writing, reporting, etc., but may be deep down another Edison. Hopefully legislators will never require you to red-tape him out of business.

Respectfully submitted,

Dan Aadland

Dan Aadland, Ph.D.
June 1, 1982

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